# International Standard 6784

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# Concrete — Determination of static modulus of elasticity in compression

*Béton — Détermination du module d'élasticité statique en compression*

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# Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 6784 was developed by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, and was circulated to the member bodies in January 1980.

It has been approved by the member bodies of the following countries :

| | | |
|---|---|---|
| Australia | Greece | Poland |
| Austria | India | Romania |
| Belgium | Ireland | Spain |
| Brazil | Israel | Sweden |
| Chile | Italy | Switzerland |
| China | Korea, Rep. of | Thailand |
| Czechoslovakia | Netherlands | United Kingdom |
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

Bulgaria
Germany, F.R.
South Africa, Rep. of



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# Concrete — Determination of static modulus of elasticity in compression

## 1 Scope and field of application

This International Standard specifies a method for the determination of the static modulus of elasticity in compression of hardened concrete, on test specimens which may be cast or taken from a structure.

Static modulus of elasticity in compression, $E_c$, is known as the secant modulus[1], which, in newtons per square millimetre[2], is calculated from the formula

$$E_c = \frac{\Delta\sigma}{\Delta\varepsilon}$$

where $\Delta\sigma$ and $\Delta\varepsilon$ are the differences in stress and strain, respectively, between a basic loading level of 0,5 N/mm² and an upper loading level of one-third[3] of the compressive strength of the concrete.

## 2 References

ISO 1920, *Concrete tests — Dimensions, tolerances and applicability of test specimens.*

ISO 2736, *Concrete — Sampling, making and curing of test specimens.*[4]

ISO 4012, *Concrete — Determination of compressive strength of test specimens.*

ISO 4013, *Concrete — Determination of flexural strength of test specimens.*

ISO 6275, *Concrete, hardened — Determination of density.*

## 3 Apparatus

The apparatus comprises a testing machine complying with the requirements of ISO 4012. It shall be capable of applying the specified load at the specified rate and maintaining it at the required level.

Instruments (for example mirror or dial gauge extensometers, resistance strain gauges, inductance gauges, vibrating wire strain gauges) for measuring the changes in length shall have a gauge length of not less than two-thirds of the diameter of the test specimen (2/3 $d$) and shall be attached in such a way that the gauge points are equidistant from the two ends of the specimen and at a distance not less than one quarter of the length of the test specimen ($L/4$) from its ends.

Measurements shall normally be taken on not less than two opposite sides of the specimen. With specimens cast in a horizontal position, the gauge lengths should be arranged on the vertical sides as cast.

The measuring apparatus shall have an accuracy of $\pm 5 \times 10^{-6}$.

## 4 Test specimens

The test specimens shall preferably be cylinders of diameter 150 mm and height 300 mm. Alternatively, other test specimens generally complying with the requirements of ISO 1920 may be used, provided that the length/diameter ratio is in the range $2 \leqslant L/d \leqslant 4$ and the diameter $d$ is at least four times the nominal maximum size of the aggregate in the concrete.

In the case of specimens drilled or cut from a structure, these requirements cannot sometimes be fulfilled; in such cases, this shall be stated in the test report.

## 5 Preparation of test specimens

The test specimens shall be made and stored in accordance with ISO 2736. The dimensions shall be checked in accordance with the relevant procedures given in ISO 4012 or ISO 4013, and the specimens shall be prepared for testing in accordance with ISO 4012.

1) In some countries, the term "chord modulus" is used.

2) 1 N/mm² = 1 MPa

3) In special cases, other upper load levels between one-quarter and a half of the compressive strength may be used, but this shall be stated in the test report.

4) At present at the stage of draft.

If other curing procedures are used, for example in the case of drilled or cut specimens, this shall be clearly stated in the test report.

## 6 (Apparent) density

Determine the (apparent) density of the test specimens in accordance with ISO 4012 or ISO 6275.

## 7 Procedure

### 7.1 Determination of compressive strength

Determine the compressive strength of the concrete on three companion specimens, of the same size and shape as those to be used for the determination of the static modulus of elasticity, and made and cured under similar conditions[1], by the method specified in ISO 4012.

The mean value of the compressive strength, $f_c$, determines the stress applied in the determination of static modulus of elasticity.

### 7.2 Determination of static modulus of elasticity

Place the test specimen, with the measuring instruments attached axially, centrally in the testing machine. Apply the basic stress, $\sigma_b$, i.e. 0,5 N/mm$^2$, and record the strain readings taken at each measurement line.

Steadily increase the stress at a rate of 0,6 ± 0,4 N/mm$^2$ per second until the stress equal to one-third of the compressive strength of the concrete ($\sigma_a = f_c/3$) is reached. Maintain the stress for 60 s and record the strain readings taken during the succeeding 30 s at each measurement line. If these strains differ by more than 20 % from their mean value, recentre the test specimen and repeat the test. If it is not possible to reduce the differences to below 20 %, disregard the test result.

When the centering is sufficiently accurate, reduce the load, at the same rate as during loading, to the level of the basic stress. Carry out at least two additional preloading cycles, using the same loading and unloading rate, and maintaining the stress ($\sigma_a$ and $\sigma_b$) constant for a period of 60 s. After completion of the last preloading cycle and a waiting period of 60 s under the stress $\sigma_b$ = 0,5 N/mm$^2$, record the strain readings, $\varepsilon_b$, taken during the succeeding 30 s.

Reload the specimen to stress $\sigma_a$ at the specified rate, and record the strain readings, $\varepsilon_a$, taken within 30 s.

When all elasticity measurements have been completed, increase the load on the test specimen, at the specified rate, until failure of the specimen occurs. If the compressive strength of the specimen differs from $f_c$ by more than 20 %, this shall be noted in the test report.

## 8 Expression of results

Calculate the mean strains, $\varepsilon_a$ and $\varepsilon_b$ respectively at the various measurement lines in the measuring load cycle (following the centering and carrying out at least two preloading cycles).

The static modulus of elasticity in compression, $E_c$, in newtons per square millimetre, is given by the formula

$$\frac{\Delta\sigma}{\Delta\varepsilon} = \frac{\sigma_a - \sigma_b}{\varepsilon_a - \varepsilon_b}$$

where

$\sigma_a$ is the upper loading stress, in newtons per square millimetre ($\sigma_a = f_c/3$);

$\sigma_b$ is the basic stress (i.e. 0,5 N/mm$^2$);

$\varepsilon_a$ is the mean strain under the upper loading stress;

$\varepsilon_b$ is the mean strain under the basic stress.

Round the result to the nearest 500 N/mm$^2$ for values over 10 000 N/mm$^2$, and to the nearest 100 N/mm$^2$ for values below 10 000 N/mm$^2$.

## 9 Test report

The test report shall include the following information :

### 9.1 Data to be given by the producer of the test specimen

#### 9.1.1 Mandatory data

a) identification of the specimen;

b) date of production of the concrete (and of the specimen, if different);

c) conditions of curing and storage;

d) required age of the specimen at the time of testing, or date of testing if the age is not known.

#### 9.1.2 Optional data

e) building project;

f) part or component of the building;

g) (specified) class of compressive strength, according to ISO 3839;

h) mix data.

1) If, exceptionally, companion specimens are not available, the compressive strength may be estimated and the basis of the estimate reported.

### 9.2 Data to be given by the test laboratory

a) condition of the specimen when received, and any surface treatment;

b) type and dimensions of the specimen;

c) conditions of curing and storage;

d) date of test;

e) age of the specimen;

f) apparent density of the specimen;

g) type and number of measuring instruments and the gauge length;

h) compressive strength of the companion specimens;

j) compressive strength of the specimen used for the determination of the static modulus of elasticity;

k) static modulus of elasticity;

m) remarks.